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Technical
Supplement to the
Fifth Growth Policy Report
of the Montgomery County Planning Board
June, 1979

PLANNING, STAGING AND REGULATING

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Supplement #2

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Transportation Modeling Procedures

Transportation Planning Division
Montgomery County Planning Department
Maryland-National Capital Park
and Planning Commission
September 17, 1979

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TRANSPORTATION MODELING PROCEDURES

1. Introduction

The Fifth Annual Growth Policy Report of June 1979 on Planning, Staging and Regulating proposes an amendment to the adopted General Plan for Montgomery County, which would provide for a Comprehensive Staging Plan element. The staging plan would set a.) residential and non-residential threshold ceilings on growth within defined Policy Areas in the County and b.) give guidance to the capital programming of State, regional and County public facility improvements. The thresholds would be keyed to the provision of adequate public facilities required to support the growth. Transportation and sewer facilities are the critical elements which guide the staging plan.

The relationship between recommended staging thresholds and adequate transportation facilities is determined through the application of a computerized transportation model and interpretation of model results. This document is intended to provide information on the transportation modeling procedures used in the Growth Policy Report. Background information will be provided on the origin of the model and its refinement for use in Montgomery County under an UMTA/FHWA grant. The reasons for selecting a modeling approach will be discussed and references will be made to the Fourth and Fifth Annual Growth Policy Reports which proposed the use of the model and presented model results in those years. Finally, details of the model itself will be presented including input data, zone structure, network structure, model sequence, assumption and output data. This paper is not intended to be a users manual on the transportation model nor will it discuss in detail the results of model application and interpretation of those results. The users manual and other pertinent back-up technical material will be referenced.

This paper is the second in a series of three supplemental papers on the transportation portion of the Fifth Annual Growth Policy Report. Producing such supplemental papers has been done as part of previous annual reports. The first supplemental paper reviews the measurement standards for the Total Transportation Level of Service Concept. The third supplemental paper gives specific replies to an extensive list of questions formulated after an initial public seminar on the transportation modeling procedures. Those replies are being given general distribution because they are probably representative of the kinds of questions which might be on the mind of other citizens.

2. Background

The Corridor Cities Transportation Impact Study (CCTIS) was initiated in 1976. The project was jointly funded by M-NCPPC, UMTA and FHWA. The study had four principal parts 1) selection of specific transportation modeling analytical methods and procedures, 2) input preparation, 3) model application and analyses, and 4) work product reports and documentation.

Comsis Corporation, a transportation consulting firm, was selected to assist the staff of M-NCPPC and the Council of Governments (COG) in conducting the study. Two other subcontractors, NLT Computer Services and Applied Urbanetics, were used to provide data processing and computer graphics services. The entire study was designed to produce a functioning transportation model adapted for continuing use in Montgomery County. M-NCPPC staff was trained by Comsis during the course of the study and now continues to apply the model with computer services still being provided by NLT and Applied Urbanetics.

During the course of the CCTIS study a technical advisory committee was used to guide and critique the work of Comsis Corporation and the M-NCPPC staff. Members of the committee represented Montgomery County DOT, Maryland DOT, Cities of Rockville and Gaithersburg, WMATA and COG. The transportation model was developed for use by all agencies dealing with transportation planning and implementation in Montgomery County. The model has been used in this manner for State and County project planning studies of major transportation facilities and by the City of Rockville.

A. The Fourth Annual Growth Policy Report - Carrying Capacity and Adequate Public Facilities introduced the concept of a County-wide staging element of the General Plan.

> "The process would work as follows. The present APF Ordinance would remain in effect for all preliminary plans on septic tanks or other small separate waste treatment systems, whether inside or outside the ten-year sewer envelope. A County-wide staging element of the General Plan would be developed that would establish growth thresholds for subareas of the County within the ten-year sewer envelope. These growth thresholds would be established by a planning judgment that derived from an analysis of all the public facility systems as reflected in the six-year CIP.
>
> This County-wide staging element of the General Plan would be prepared by the Planning Board and presented for public scrutiny and formal adoption. Once adopted,

these growth thresholds would be incorporated by amendment into the Ten-Year Water and Sewerage Plan. This, in turn, would guide the Sanitary Commission in its process of releasing sewer authorization to approved preliminary plans on a first-come, first-served basis, within each subarea of the County, up to the limit of the subarea's established threshold capacity.

Developers would be aware of the threshold capacities in each subarea, but could file preliminary plan applications regardless of the number of other previously approved preliminary plans in that area. They would know, however, that their prospect of receiving sewer authorization in an over-subscribed area would depend on some of those ahead of them dropping out. On the other hand, the existence of a known list of outstanding preliminary plan applications could also be used by County government as an indicator of need for additional public facility expansion; and the CIP could be amended to shift fiscal resources to those areas where the accumulating need was greatest. The threshold ceilings of the subareas could be keyed to the provision of specific capital projects and a cyclical planning and evaluation process introduced, by which to better relate the forecasting of growth needs to the programming of public facilities."

B. <u>The Fifth Annual Growth Policy Report</u> - Planning, Staging and Regulating proposes an amendment to the General Plan implementing the growth threshold staging concept. The proposed staging threshold cover employment and housing for geographic policy areas within the County.

The need to approach growth management from a comprehensive prospective and to administer the Adequate Public Facilities Ordinance using staging thresholds derives from what can be called the "scale dilemma". It consists of four parts: 1) the "pattern" issue, 2) the "equilibrium" issue; 3) the "substitution" issue, and 4) the "combination" issue.

The "pattern" issue is characterized by the problem associated with the contrast between a "variable" rate of traffic flow, implied by the natural urban landscape, and a "constant" rate of traffic flow, implied by the use of a single standard level of service measure at all major intersections. Since the current method of dealing with subdivisions on a one-by-one basis does not lend itself to a variable level of service standard required when viewing the County-wide situation, the "pattern" issue is one facet of the scale dilemma.

The "equilibrium" issue derives from the observation that private growth occurs in small increments while public facilities provide for large increments of growth. A major roadway can accommodate growth from numerous subdivisions. Graphically, private growth over time is a relatively smooth curve composed of small increments, whereas public facilities are portrayed as a step function with large capacity increments separated by intervening time periods. The points of equilibrium between private growth needs and public facility capacity are limited in duration. A feast or famine occurance is not uncommon.

The "substitution" issue deals with modal split between automobiles and transit. If transit is available and attractive people may substitute transit for roadways which will result in the total transportation system increasing its capacity without any change in the level of service experienced on the roadways.

The "combination" issue deals with the cummulative impact of numerous small changes in urban land use and transportation patterns It is possible that changes in any individual subsystem alone would not be excessive or even measurable, however, combined with simultaneous changes in the same and other subsystems might result in an aggregate impact of significant dimension.

C. Reasons for Computer Model

A transportation computer modeling technique was chosen to deal with the issues associated with the scale dilemma. The model is required to project transportation conditions in future years. Complicated land use and transportation alternatives can be simulated for future years using a gravity type transportation model. The model can replicate a given procedure in the same manner so that marginal changes can be analyzed and if necessary, the whole simulation could be run again.

The interactive effect of future development inside and outside Montgomery County can be analyzed using the type of regional transportation model utilized in the Growth Policy. The model can also ascertain the cummulative impact of numerous small changes to future land use patterns. The effect of highway and transit improvements can be isolated and the dependence of development on any one or group of improvements determined.

D. Basis of Staging Plan

In the Fifth Annual Growth Policy Report the transportation model results were combined with output from other functional elements of adequate public facilities to formulate a staging plan. The plan has as a basis a total transportation level of service concept. The County

is divided into four categories of transit availability depending on the frequency and types of transit planned for 1985 and 1995 time frames. Within the four categories, geographic units having like traffic flow characteristics are established and called traffic sheds. Staging constraints are applied at the traffic shed or grouping of traffic sheds level. The staging is based on standards of acceptable levels of highways congestion for traffic sheds with the standard varying according to the type and frequency of transit service planned to be available.

The projected level of highway congestion is derived from the transportation computer model. The principal output from the model is daily traffic volumes assigned to the highway links in the network i.e. Average Daily Traffic (ADT). For each traffic shed the ADT is converted to vehicle miles of travel (VMT) by multiplying ADT by the length of each network link. Finally, the VMT is accumulated and summarized by classes of volume to "capacity" (V/C) ratios. The "capacity" is the service volume at level of service "C". The Highway Congestion Level Indicator is the percentage of VMT within a traffic shed exceeding a V/SVC ratio of 1.6.

Obtaining a balance between land use and planned and proposed transportation elements is the objective of the staging plan. To do this a staging limitation is placed on dwelling units and employees within traffic sheds. The limitation is based on the abaility of the transportation facilities to accommodate the projected growth without exceeding the Highway Congestion Level Indicator appropriate for the transit availability in the specific traffic shed. The process is, by design, iterative. Balance can be obtained by changing any one of the three variables; land use, highway facilities, or transit facilities.

Changing land use will increase or decrease the number of person trips produced or attracted to a traffic shed and thus will impact the ADT used to compute the Highway Congestion Level Indicator. Adding or deleting highway facilities will affect the capacity portion of the V/SVC ratio and therefore will also influence the Highway Congestion Level Indicator . Changing the type of transit service available in the traffic shed will influence the mode split decision in the transportation modeling procedure and in turn change the ADT assigned within the traffic shed. A change in transit may also change the criteria for acceptance of the Highway Congestion Level Indicator with more congestion being accepted where more transit is available.

3. Transportation Model

The basic transportation model used in the Growth Policy work effort was developed by the Metropolitan Washington Council of Governments (COG). It is named TRansportation Integrated Modeling System (TRIMS). As shown in Figure 1, the flow chart of the model incorporates a series of traditional submodels for trip generation, trip distribution, modal split and trip assignment (Figure 1).

The model is designed to simulate regional transportation conditions for all jurisdictions which make up COG. The transportation network and land use information covers all jurisdictions. In processing a modified version of TRIMS for the Growth Policy, all land use and network information at the district level of detail was obtained from COG. This assures consistency with regional transportation modeling efforts and safeguards against a Montgomery County staging plan that is based on an unbalanced regional land use and transportation plan.

Modifications to TRIMS made under the FHWA/UMTA grant were designed to focus the regional model on Montgomery County. To accomplish this two major work efforts were undertaken. The first involved changes to the input/output mechanisms and the second was a complete updating of the Montgomery County district/zone structure, transportation networks and land use information.

A. Modification to Input/Output Procedures

The regional TRIMS model uses card input and has a standard set of formated paper output. A major portion of the Comsis Corporation work effort was the installation of the FYLSYS data management system. All input information is now stored in data sets on tape which can be called for and put into TRIMS format in a very simplified manner. The data can be temporarily or permanently modified with ease. Because the input is in a storage/retrieval file it can be compared in an analytical manner with other data sets such as showing the absolute differences between two alternate sets of land use data.

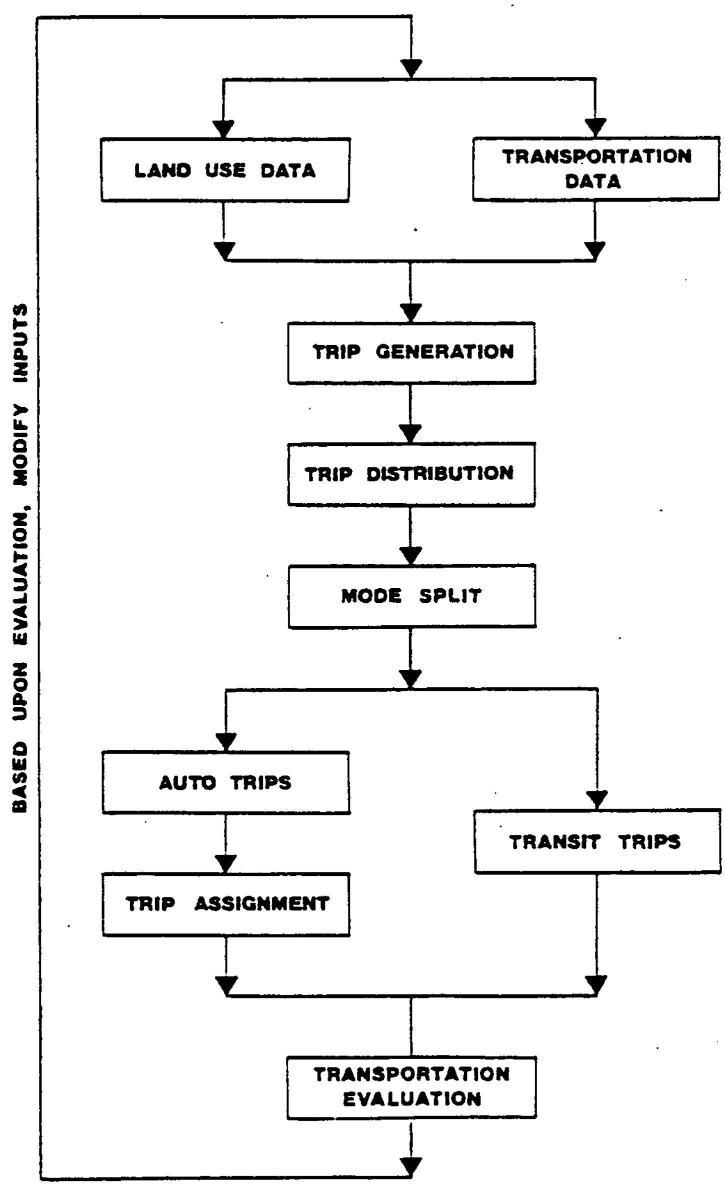
The FYLSYS package also serves an important function in the output of modeled information. The standard hard copy computer sheets are printed as usual, but in addition key model results are permanently stored in FYLSYS. This very important feature allows the output to be analyzed in a variety of ways and for the output of different runs to be compared to one another. An important example is the computation of the Highway Congestion Level Indicator which is accomplished external to TRIMS.

Figure 1

Flow Chart of the Transportation Model

Figure 2.3

TRANSPORTATION MODEL OUTLINE



A second modification to the output procedures was the incorporation of the FHWA PLANPAC computer graphics package. This mechanism allows input or output data to be displayed graphically using the CALCOMP flat-bed plotter. Three types of plots are available including: 1) band width and band width differences, 2) multicolored range information on links and 3) two pieces of numerical information on each link. This last type of plot is most useful in displaying information such as ADT volumes, input speeds, calculated V/SVC ratios and volume to volume ratios between alternative runs. The plotting capability is extremely useful in observing county-wide patterns and trends which can only be visualized graphically.

B. Updated Traffic Zones, Networks and Land Use

Updating the district/traffic zone boundaries in Montgomery County was undertaken to bring the transportation modeling data collection boundaries in conformance with the Planning Area boundaries established by the Planning Board and County Council. Now, traffic zones can be aggregated to form Planning Areas. Traffic zones can also be aggregated to other analysis areas such as Traffic Sheds or Policy Areas. In the process of revising the boundaries several other objectives were met. Physical barriers which have a limited number of crossings such as the B&O railroad, I-270 and major stream valleys were used to form traffic zone boundaries. Established CBD areas in Silver Spring, Friendship Heights and Bethesda were defined along with greater attention being paid to transit station sector plan boundaries. Areas under special study through the Master Plan process were identified. Finally, each traffic zone was reviewed to make sure it made sense from a trip production/attraction point of view.

The transportation networks were similarly updated for Montgomery County. A more detailed network, which for the first time included certain County arterials, was installed. The input data for each link, such as width, length and classification was verified. Centroid connections from traffic zones to the new network were determined based on the most logical access points to the arterial and major highway system. Future transit patterns were derived from Master Plans and Sector Plans and the Conceptual Design of Transit Services which was developed as part of the transit analysis for the 1975 Growth Policy Report. Finally, the State 20-Year Needs Study and other sources were used to formulate a comprehensive set of possible highway projects from which future networks could be easily built.

The land use for Montgomery County was updated for 1975 for the new traffic zones. Future projections for 1985 and 1995 were made for each zone for dwelling units, group quarters and employment by office, retail, industrial and other categories.

C. Description of TRIMS Model

The following section is taken from the TRIMS model Users Manual, developed by William Mann of COG, to which the reader can refer for more detailed information. TRIMS (TRansportation Intergrated Modeling System) is a computer program that has chained together all of the essential transportation planning models and techniques into one program. No new travel estimating approach has been used. Instead, the traditional four step approach to travel forecasting (trip generation, trip distribution, modal split, and traffic assignment) is performed in one execution. It also has the capability to do capacity restraint and selected link analysis within the same one execution. Network formats are Federal Highway Administration (FHWA) formats and TRIMS has an option to read or write trip tables on tape in FHWA format. This permits TRIM to interface with FHWA transportation planning programs.

TRIMS can provide sufficient detail for sketch planning at the district level (185 areas), and it can focus in on a particular area to provide detailed data for a zone level (500 areas) analysis. All traffic modeling is performed at the district level; the resulting trip table is then split to zone level based on zone land activities and assigned to the zone level network. These "zones" can be zone level throughout the region or they can be located in the subarea only with the original districts outside the subarea. The Corrider Cities adaptation of the TRIMS model uses a) the initial district level runs of the model and b) then uses finer zones only within the County.

While this approach is not new; it is easier and cheaper to use than traditional methods. It is cheaper because the entire modeling chain is performed internally in the computer without writing or reading intermediate outputs on disk or tape. This reduces both computer time and the time required by highly specialized computer personnel to manipulate data sets. It is easier to use because the user has to code parameter cards for only one program rather than several programs and his need for understanding and coding job control language is practically eliminated. The actual coding of input data is also streamlined which minimizes personnel time.

The structure of the TRIMS model is based on the assumption that within the area where detailed analysis is required, zone sizes must be small and as one goes further away from the analysis area, larger zones can be used. For this reason the travel forecasting model sequence is applied to movements between districts through modal split. The resulting inter-district trip table is then allocated from districts to zones for traffic assignment to a network reflecting zone level of detail. That network is limited to 3000 nodes. The inter-district network, used to obtain inter-district travel times, is limited to 1200 nodes. These limitations have been used nearly to their fullest in the Corridor Cities adaption of the TRIMS model.

The overall sequence in which each major phase of these models is executed is illustrated in Figure 2. While Figure 2 shows only the major sequence of events within the model, there are many other summaries that can be obtained after each phase. For example, for each trip table created, a trip length frequency is formatted. Also, each trip table distribution can be compressed and formatted into a 20 X 20 matrix in order to obtain a summary of movements between jurisdictions or other large areas.

The capabilities and limitations of TRIMS are described and discussed in the following pages under the categories of networks, models, trip splitting, traffic assignments, and capacity restraint.

(1) Highway and Transit Networks

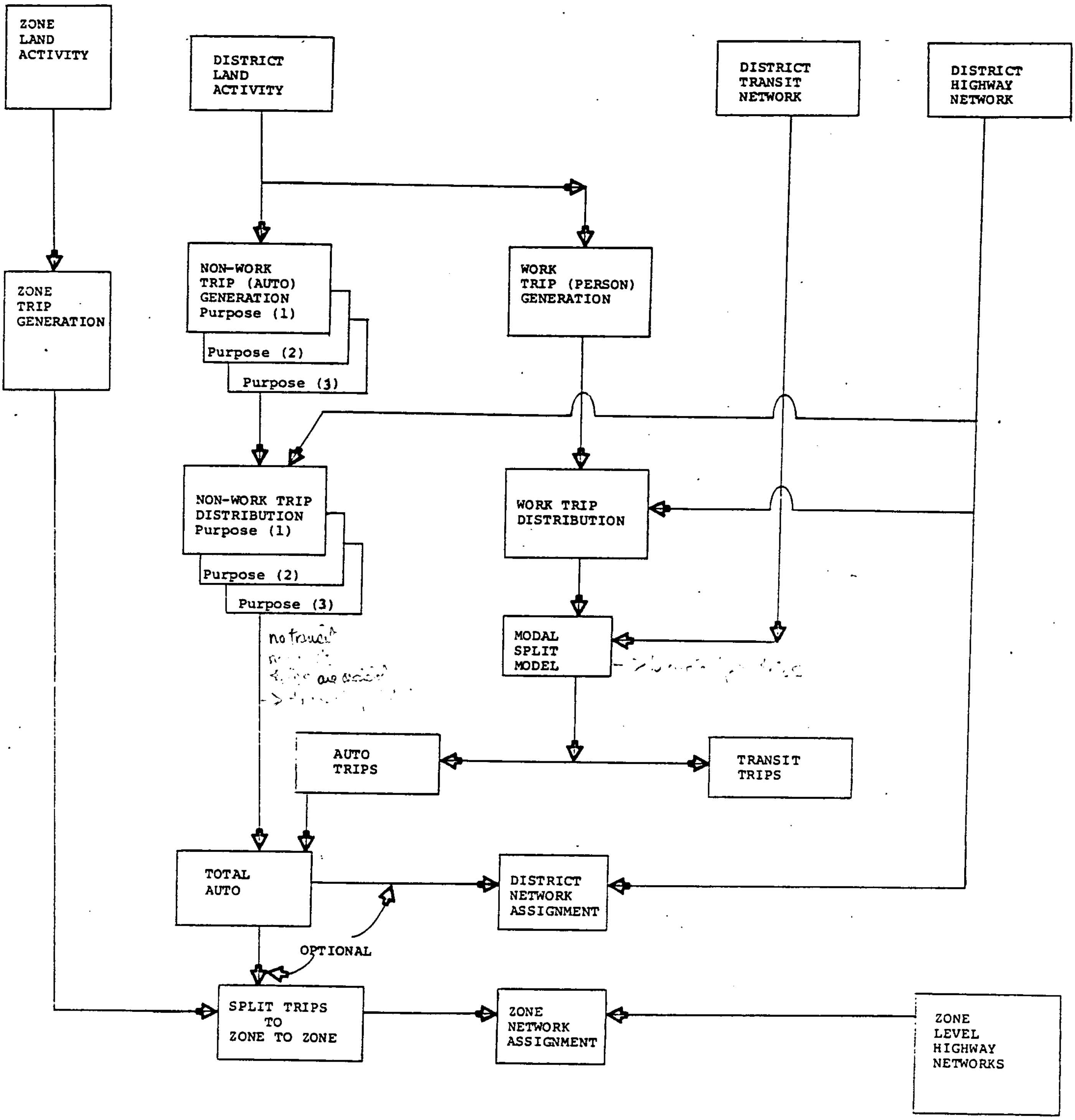
The program allows for three types of networks - a district level highway network (principal roadways only), a district level transit network, and a zone level highway network. Both the district level and zone level highway networks are coded in a format that can be read by Federal Highway Administration (FHWA) transportation planning computer programs. The transit network is a sketch planning network. As a minimum, the highway network requires A-node, B-node, distance, and speed. Ground counts and capacities must also be provided if capacity restraint is to be used in the assignment procedure. In addition, route type codes and area location codes must be provided if various assignment summaries such as vehicle miles of travel (VMT) by route type and by location are desired. The data required for a typical network link is shown in Table 1.

More specifics on coding the district highway, the district transit, and the zone highway networks are as follows:

a. District Highway Network: This network, with a limitation of 1200 nodes and 150 districts, is easy to code and modify because it consists of principal roadways only. For example, adding an outer beltway to test its impact on an existing beltway could be done with relative ease. Non link specific variables (those associated with the analysis areas, the traffic districts) which must be provided to obtain total vehicle district skim trees are intra-district driving times, origin access times, and destination terminal times.

b. District Transit Network: A sketch planning technique is used to describe the transit network. The coding is similar to the district highway network, a transit speed must also be coded. These speeds represent a weighting of all transit lines in the corridor represented by the link. For links without any transit service, a zero mile per hour speed is recommended. Since lines and headways are not coded, the user

Figure 2



"TRIMS Model" Sequence

Source: COG's TRIMS Users Manual

Table 1

CARD TYPE 7 - NETWORK CARDS (See Parameter Card, Field 22)

Field	Data	Card Column
1	A-Node	3-6
2	B-Node	9-12
3	Distance (x.xx)	15-17
4	Directional VPH/ADT factor (.xxx) If left blank, the default is from Card Type 3	29-31
5	Directional Ground Count (daily and in hundreds)	32-34
6	Direction Code: Alpha S = 2-way link 0 or blank = 1-way link	41
7	Number of lanes; code the sum of both directions. Zero is a valid code and would cause a zero capacity which would eliminate capacity restraint in the loading process, if desired.	64-65
8	Route Type (Only codes 0-5 are allowed). Default is 0. Codes greater than 5 are changed to 5.	66
9	Location Code. The first digit is Ring; the second jurisdiction. Default is 01.	69-70

Source: COG's TRIMS Users Manual

must code for each district an origin walk time, a destination walk time, and seven wait times. These seven wait times represent the average waiting time, plus transfer times; from each origin district to each of seven different destination areas within the region. These other destination areas are defined by the present and future orientation and extent of transit service, and recognize constraints such as the Potomac River and that service to areas further away from the County will require greater wait times.

c. Zone Highway Network: There are two possible techniques for creating a zone level highway network. One procedure is to code delete-and-add-cards for updating the district network while the other procedure is to code and build a completely new network. For the Growth Policy analysis, a new network was created for Montgomery County. This zone network can have as many as 500 zones and 300 nodes. Substantial savings in computer costs accrue by using zone level assignments for only a portion of the region, with the remainder of the area represented at the more general district level. This procedure was used with zone level detail employed inside Montgomery County and district level outside. should do same for transit at [illegible]

d. Calculation of Daily Highway Capacities: It was indicated above that capacities must also be provided if capacity restraint is to be subsequently used in the assignment of vehicular trips to the zone level highway network; which is the case in this application of the model. These capacities are a function of type of road and location in the metropolitan area and are determined by a table-look up procedure which is carried out as one of the preparatory steps in running the model. The look-up starts with hourly "capacities" in Table 2A which are service volumes at Level of Service C, and have been developed by COG based upon the Highway Capacity Manual. "Daily capacities" are obtained by multiplying the directional hourly "capacity" shown in Table 2A, by the number of lanes, adding both directions together and dividing that sum by the peak hour factors shown in Table 2b.

(2) Specific Travel Demand Models

The trip table used in the network assignment evaluation can be a fixed trip table read from tape in FHWA format or TRIMS can generate its own trip table. The trip table submodels built into TRIMS are: trip generation, trip distribution, modal split, and car occupancy. There is no limit to the number of trip generation and trip distribution models that can be used. The mode split and car occupancy models are applied to the first purpose, usually work trips, only.

Bob
FYI (from COG meeting)

TRIP GENERATION RATES

Revised 12/79

(for all years from 1977-2000)

( ) = inc. from 1979

PRODUCTIONS

HBW

	- 10 Mi. Sq. -				
	Core	D.C.	VA.	Suburbs	Exurbs
HH	1.00	1.88	1.88	2.00	2.00
GQ	0.26	0.15	0.15	0.15	0.15

HBS

	- 10 Mi. Sq. -					
	Core	D.C.	VA.	Suburbs	old rate	Exurbs
HH-LI	0.12	0.58	0.69	(0.88	.75	1.10
HH-HI	0.12	0.68	0.81	1.19	1.23	1.49
GQ	0.05	0.31	0.26	(0.34		0.43

HBO

	- 10 Mi. Sq. -					
	Core	D.C.	VA.	Suburbs		Exurbs
HH-LI	0.40	0.88	1.05	(1.15)	1.21	1.44
HH-HI	0.40	1.18	1.41	(1.60)	1.66	2.00
GQ	0.29	0.80	0.95	1.21		1.51

NHB

	- 10 Mi. Sq. -				
	Core	D.C.	VA.	Suburbs	Exurbs
Off.	0.09	0.15	0.15	0.28	0.35
Ret.	0.73	2.09	2.49	2.52	3.15
Oth.	0.17	0.26	0.31	0.34	0.43
HH	0.13	0.13	0.12	0.12	0.15

ATTRACTIONS

HBW

1.44 x TOTAL EMPLOYMENT

HBS

	- 10 Mi. Sq. -				
	Core	D.C.	VA.	Suburbs	Exurbs
Ret	0.33	2.31	4.04	6.04	7.55

will drop as area matures

HBO

	- 10 Mi. Sq. -				
	Core	D.C.	VA.	Suburbs	Exurbs
Off.	0.09	0.17	0.11	0.27	0.34
Ret.	0.88	1.12	1.50	1.57	1.96
Oth.	0.44	0.70	1.17	1.52	1.90
HH	0.22	0.27	0.28	0.30	0.38

NHB

Same as NHB PRODUCTIONS

ABBREVIATIONS

HBW - Home Based Work Person Trips
HBS - Home Based Shop Auto Driver Trips
HBO - Home Based Other Auto Driver Trips
NHB - Non-Home Based Auto Driver Trips
HH - Households
LI - Low Income (below median income)
HI - High Income (above median income)
GQ - Persons in Group Quarters
OFF - Office Employment
Ret - Retail Employment
Oth - Other Employment
Exurb - P.W. Co. & Loudoun Co. (excludes districts west of Goose Creek - Districts 167 thru 171)

Table 2 Factors Used in Calculating "Daily" Capacity

Table 2A. Capacities in Vehicles per Hour per Lane at Service Volume C, Directional

Class of Roadway	Location in Region: District of Columbia and Arlington Core	Location in Region: Remainder of Region
Freeway	1300	1300
Expressway	720	930
Principal	580	750
Minor	460	600
Collector	310	400

Table 2B. Peak Hour Traffic as a Percent of Average Daily Traffic

Class of Roadway	Ring 0, 1: D.C. and Arlington Core	2, 3: Remainder of 10 mile square	4, 5: Inner Suburban (either side of Beltway)	6, 7, 8: Outer Suburban
Freeway	10	11 1300/.12 = 10,833	12 4 la = 43,333 6 la = 65,000 8 la = 86,666	12
Expressway	11 930/.13 = 7153	12 930/.12 = 7750	12 4 6 31,000 46,500	13 28612
Principal	11 750/.13 = 5769	12 750/.12 = 6250	12 2 4 6 12500 25000 37500	13 11538 23076 34615
Minor	12 600/.14 = 4286	12 600/.13 = 4615	13 2 4 9230 18460	14 8572 17144
Collector	12	13 400/.14 = 2857	14 2 4 5714 11428	14

X 1.6

Fwy 4 6 8 69 333 104 000 138 666 138 [illegible]

Exp 4 6 49 600 74 400 45 780 68 670

Prin 2 4 6 20,000 40 000 60 000 18 460 36 920 55 380

Minor 2 4 14 768 29 536 13 725 27 430

Coll 2 4 9142 18 285

Source: COG's TRIMS Users Manual

a. Trip Generation Model: The trip generation model calculates the number of total daily person trips, for several trip purposes, beginning and ending in each analysis area. This model is based on two household variables and four employment variables, as shown in Table 3, totaling six land activity variables. Each district must be slotted into one of three household categories of low, middle, or high income. The table shows (1) trip generation coefficients for each of the six land activity variables for each of the four area stratifications as well as (2) coefficients for each of the three household stratifications. These variables and coefficients are used to determine district level trip productions and attractions by purpose.

Special adjustment factors can be applied to the results of the trip estimating equation by district and by purpose. For example, if a specific district has a shopping trip rate per retail employee that is different from the regional model then this specific rate could be coded to override the regional equation by using this option in the program. This option also allows the user to exogenously calculate productions and attractions and enter these calculated values.

b. Trip Distribution Model: A gravity model is used in the trip distribution phase. The product of the trip distribution phase is a matrix, or trip table, showing the interchange of trips between pairs of districts, including external stations. The gravity model develops the district trip table by apportioning trips in a direct relationship to productions and attractions and in an inverse relationship to the travel time between districts.

The trips to be apportioned in the trip distribution model are derived from the trip generation model. Both work and non-work trip purposes are separately distributed. The non-work trips are vehicular trips and once distributed go directly to the zone level trip splitting process. The work trips are person trips and therefore a modal split model must be employed prior to the zone level trip splitting.

In the trip distribution process, the gravity model is applied to internal districts and external stations alike. Through trips are exogenously calculated and added to the results separately. Typical "F" curves used in trip distribution are shown in Figure 3. The "F" value derived from the curves is a measure of the attractiveness of a trip interchange between paris of districts. A high "F" value indicates a strong attraction.

Table 3

TRIP GENERATION RATES

PRODUCTIONS

HBW	Core	-10 Mi Sq-- D.C.	VA.	Suburbs
HH	1.00	1.88	1.88	2.00
GQ	0.26	0.15	0.15	0.15

HBS	Core	-10 Mi Sq-- D.C.	VA.	Suburbs
HH-LI	0.07	0.38	0.45	0.75
HH-MI	0.12	0.58	0.69	0.92
HH-HI	0.12	0.68	0.81	1.23
GQ	0.05	0.31	0.26	0.34

HBO	Core	-10 Mi Sq-- D.C.	VA.	Suburbs
HH-LI	0.31	0.55	0.65	1.21
HH-MI	0.40	0.88	1.05	1.35
HH-HI	0.40	1.18	1.41	1.66
GQ	0.29	0.80	0.95	1.21

NHB	Core	-10 Mi Sq-- D.C.	VA.	Suburbs
Off.	0.09	0.15	0.15	0.28
Ret.	0.73	2.09	2.49	2.52
Oth.	0.17	0.26	0.31	0.34
HH	0.13	0.13	0.12	0.12

ATTRACTIONS

HBW

1.44 x TOTAL EMPLOYMENT

HBS	Core	-10 Mi Sq-- D.C.	VA.	Suburbs
Ret	0.33	2.31	4.04	6.04

HBO	Core	-10 Mi Sq-- D.C.	VA.	Suburbs
Off.	0.09	0.17	0.11	0.27
Ret.	0.88	1.12	1.50	1.57
Oth	0.44	0.70	1.17	1.52
HH	0.22	0.27	0.28	0.30

NHB

Same as NHB PRODUCTIONS

ABBREVIATIONS

HBW - Home Based Work Person Trips
HBS - Home Based Shop Auto Driver Trips
HBO - Home Based Other Auto Driver Trips
NHB - Non-Home Based Auto Driver Trips
HH - Households
LI - Low Income
MI - Median Income
HI - High Income
GQ - Group Quarters
Off - Office Employment
Ret - Retail Employment
Oth - Other Employment

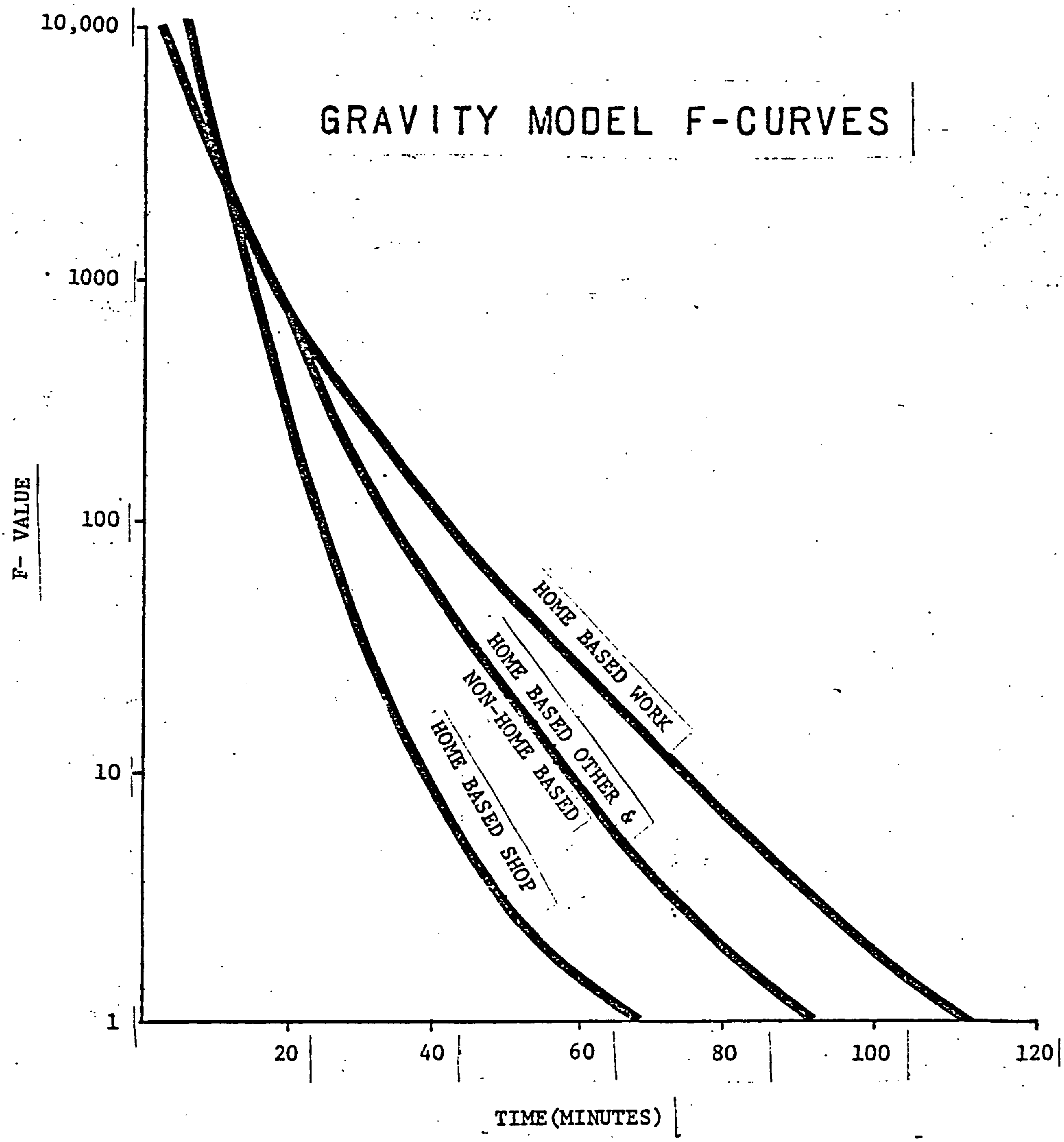
Revised 1-75

Note: Revision approved by task group of the Technical Committee, in order to produce higher traffic volumes in D.C.

Trip rates in D.C. were increased by deriving them from person trip rates used for Arlington.

Source: TPB, Transportation Planning Technical Procedures, July 1974

Figure 3. Gravity Model Friction Factors by Trip Purpose



Source: TPB, Transportation Planning Technical Procedures, July, 1974.

c. Modal Split Model: The district level person trip matrix for work is divided into vehicular trips and transit trips by the modal split model. The vehicular trips are combined with other non-work vehicular trips and form the total district level trip distribution matrix. The transit trips are kept separate and at the end of the modal split model are ready for assignment to the district level transit network. The vehicular trips can be assigned to the district level highway network and can be split to form a zone level trip distribution matrix.

The modal split model is a disutility type model. The variables used are highway times, transit times, household incomes and parking cost. Mode split curves showing how these variables influence the percentage assigned to highway versus transit are shown in Figure 4. Before calculating total highway times and transit times the out-of-vehicle times are weighted by a factor of 2.5. These weighted times are transit walk and wait times which are an average time across each district and highway access and terminal times. [illegible] adj. account for auto/bike access modes

d. Car Occupancy Model: This model is a function of household income and average parking cost, and, again, operates only on the first purpose, generally work trips. This model operates on both internal districts and on external stations.

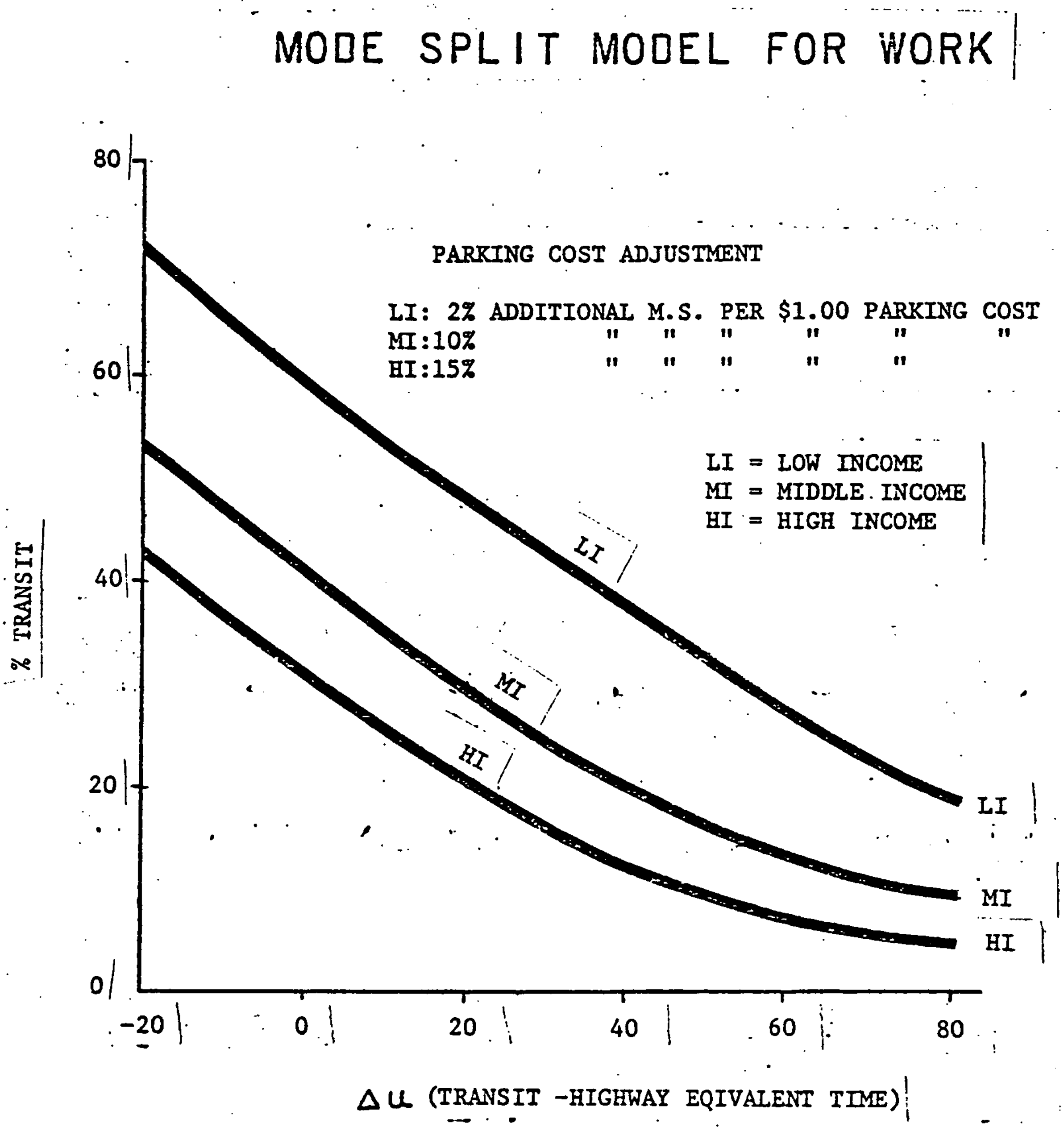
(3) Specific Traffic Assignment Models

a. Trip Splitting Model: After the inter-district table of total auto-driver trips, in production-attraction format, has been developed, these volumes can be allocated to an inter-zone matrix based on a function of six zonal land activities.

b. Assignment Model: Two methods of traffic assignment are available to the user. One is the minimum path all or nothing assignment; the other is an incremental loading with capacity restraint. The all-or-nothing assignment is very useful in measuring traffic desires while the restrained assignment is useful in obtaining more realistic assignments. In either approach, minimum paths are built once between each origin and each destination zone, and trips are also loaded once.

The capacity restraint methodology reduces the speed on the link after each incremental loading as its volume approaches capacity. For this reason, the best results would probably be obtained if restraint were applied after each single zone loading. Since this would be quite expensive, an incremental number of zones can be loaded as long as the sequence of zones selected is not bunched. The zone selection sequence methodology was taken from the Chicago Area Transportation Study. This approach first writes all numbers from 1 to 999 in reverse order, digit by digit. For example, the first number is 100, the second 200, the third 300, etc. Then, all numbers greater than the highest district number, are removed. The numbers remaining represent

Figure 4



Source: TPB, Transportation Planning Technical Procedures, July 1974.

the sequencing of district loadings. This loading sequence procedure reduces the probability of loading several origin zones that are adjacent to each other during one incremental loading.

The output of the assignment alogrithm listed for each link, whether restraint is used or not, is the a) average daily volume, b) capacity, c) volume-to-capacity ratio, d) the unloaded speed, and e) the restrained speed. If capacity restraint is not used the "restrained speeds" are the same as the coded speeds.

Assignments can be made in either origin-destination (O-D) format or in production-attraction (P-A) format. The O-D format was used for the Growth Policy analysis. If an unrestrained loading is used, the loading of trips in P-A format adds one more dimension in the evaluation It could be used in estimating peak hour directional flows and in no way sacrifices any precision in determining the two-way link assignment if all links are 2-way links. The assignment produces link volumes by direction only; turning volumes are not produced.

c. Capacity Restraint Model: The capacity restraint function developed by FHWA, is as follows: 1.6   1.6 x 1.6 x 1.6 x 1.6

2.56   4.096   6.5536

$$T = T_O \; (1 + 0.15 \; (V/C)^4)$$

6.5536

.98304

Subject to: $0 \leq V/C \leq 2$

Where: T = balance travel time (at which (V) can travel on a highway segment

T_O = unloaded travel time

V = assigned volume

C = capacity at service volume for level of service C

In solving for (T_O), unloaded travel time, (T) represents the observed travel time and (V) represents the ground count. If the count or capacity is not provided or if the coded capacity is less than the ground count then the unloaded travel time is set to equal the observed travel time. If the V/C ratio exceeds 2, it is set equal to 2, the capacity restraint function is applied to all links in the network that have a coded capacity, and the procedure is applied after a user coded number of zones.

D. Summary of Inputs and Outputs

Inputs: Input formats were designed for interfacing with FHWA software in some cases and for coding simplification in others. The network coding format is practically the same as FHWA format. The difference is in the way links with different speeds by direction must be coded. TRIMS can read and/or write binary trip tables in FHWA format.

Card formats that did not need FHWA compatibility were streamlined. An example of this streamlined coding is illustrated in the f-factor curves. Only two punched cards are used to describe f-factor curves; the first establishes time intervals and the second describes the corresponding friction value for each interval.

In summary, inputs consist of district and zone level networks, district level land activities and systems characteristics, zone level land activities, and travel demand model characteristics. A listing of all inputs (excluding networks) is shown in Table 4.

Outputs: Three of the outputs from TRIMS can be put on tape for further processing. These are the district trip table (FHWA format), district trip end summaries, and vehicle miles of travel by speed range, route type, and area codes. All other outputs are provided via the printer only. A brief summary of all possible outputs is listed in Table 5.

In addition to the standard TRIMS outputs a VMT summary routine has been developed by the transportation planning staff. It calculates VMT within geographic areas of the County by multiplying ADT assigned to a link times the length of the link in miles. The VMT is then accumulated by type of roadway and by volume to capacity (V/C) ratio ranges.

TABLE 4

LISTING OF TRIMS INPUTS

District Level Land Activities and Systems Characteristics

Households
Jobs (4 categories)
Family Income
Parking Cost
Access Time - origin - highway
Access Time - destination - highway
Access Time - destination - transit
Intra Time - highway
Intra Time - transit
Employment Density
Jurisdiction Code
Transit Origin Walk and Wait Time for Destinations in Area 1
Transit Origin Walk and Wait Time for Destinations in Area 2
Transit Origin Walk and Wait Time for Destinations in Area 3
Area Codes - 1,2,3 for Transit Walk and Wait Time
Area Codes for Trip Generation

Zone Level Land Activities

Households
Jobs (4 categories)

Model Characteristics

Trip Generation Equations
Trip Generation Adjustment Factors
F-Curves
K-Factors
Mode Split Curves (up to 3)
Car Occupancy Curves (up to 3)
Peak-Hour Model Curves (up to 9)

Source: COG/TPB, TRIMS Users Manual

TABLE 5

LISTING OF TRIMS OUTPUTS

1. District Level Network Description - A printout of the network showing A-node, B-node, distance, highway time, transit time, ground count, capacity, and route type may be obtained if desired.

2. District Level Select Trees - Up to three selected trees may be formatted for the highway network; the same trees are automatically presented for the transit network. The total time from each node to the home node is also presented.

3. System and Land Activity Listings - The district level system characteristics and land activity characteristics will be listed.

4. Land Activity Jurisdiction Totals - Jurisdiction totals for households (land activities 1 and 2) and jobs (land activities 3,4,5, and 6) will be summarized.

5. Opportunity Access - The percent of regional jobs (or any user coded land activity) within 45 (any user coded value) minutes by the highway system and by the transit system for each district will be presented. The number of households that can reach 55% (user coded value) of the regional jobs (or any user coded land activity) via the highway system and via the transit system will be presented.

6. Network Evaluation - The average travel time to reach all jobs by the highway system and by the transit system for each district will be presented.

7. Skim Trees - Inter-district highway and transit travel times may be formatted.

8. Trip Length Frequencies - Trips and percents of total trips by trip lengths will be presented for all modes and all purposes. Total person hours of travel is also presented for all modes and all purposes.

9. Trip Table Compressor - Jurisdiction to jurisdiction (codes entered on the system and land activity cards) trip tables will be presented for all modes and all purposes. Up to 10 jurisdictions are allowed.

10. Trip End Summaries - District trip ends for both origins (productions) and destinations (attractions) for all modes and for all purposes are presented. Also, total auto trip ends and total intra trips for each district are presented; these are put on tape, if desired, for processing in air quality models.

Source: COG/TPB, TRIMS Users Manual

Table 5 (continued)

11. District Network Assignments - Minimum path, all-or-nothing highway assignments or capacity restraint highway assignments will be made and formatted. Transit loadings may also be formatted if desired.

12. Composite Network Description - A composite network (district and zone level) will be formatted if desired.

13. Selected Trees for Composite Network - Up to three trees may be formatted from the composite network.

14. Composite Network Assignment - All-or-nothing minimum path assignments or capacity restrained assignments for the composite network may be obtained.

15. Assignment in P & A or O & D Format - An option allows the trip table to be loaded in production-attraction or origin-destination format.

16. Select Link - As many as eight separate select links can be summarized. District productions and attractions and a compressed trip table may be formatted for each select link

17. Select Area - A subarea may be defined by describing the internal zones in the subarea and all nodes in the network that would describe a cordon line drawn around the subarea. The assigned trips passing through these nodes would be treated as external station volumes in the subarea trip table. The resulting subarea zonal trip table is formatted to present all internal-internal, internal-external, and external-external movements.

18. District Trip Table - The district level trip table may be formatted if desired and it may also be written on tape in FHWA binary trip table format.

19. Vehicle Miles of Travel - The assignment is summarized in terms of vehicle miles of travel (VMT) by speed range (restrained speed if capacity restraint was used) by location, and by route type. This VMT summary may be written on tape for processing by air quality models if desired. Another summary shows VMT by volume-to-capacity ratio, by location, and by route type.

20. Miles of Highway - The highway network is summarized in terms of highway milage by speed range (restrained speed if capacity restraint was used), by location, and by route type. Another summary shows highway milage by volume-to-capacity ratio, by location, and by route type.

Source: COG/TPB, TRIMS Users Manual